It will be seen that the two first cuts produced no effect comparable to that caused by C. Cut A was 3 mm. deep, cut B was also 3 mm. deep on the opposite side, so that, after B had been made a bridge, 5 mm. in radial direction remained; nevertheless the rate of absorption was undiminished. Cut C was made by increasing B to the depth of 5 mm. from the bark, so that the bridge of more or less central wood finally left was 3 mm. in radial thickness, and even then the diminution was only temporary. The cuts were made about 7 cm. from the basal end, and the same distance from the first branch. Another branch of Portugal laurel showed the same thing. The wood of the branch at the point of section was about a centimetre in diameter, and contained a large proportion of old brown wood. The external envelope of white wood was cut away with the exception[1] of a bridge measuring roughly 3 × 3·5 mm. in cross section.

The result is shown in the following table:—

Time p.m. h. m.	Rate of Absorption
1 34	15
2 13	15
16	cut
19½	10
21½	11
26	13
32	14
39	13
47	14
53	15

Here again we have a diminution followed by gradual rise.

When the little bridge of younger wood was severed, the fall in rate of absorption was rapid.

Time p.m. h. m.	Rate of Absorption
5 27	16
28½	bridge severed
32	0·12
47	0·08

Thus the absorption fell to one-twentieth of the original amount; that it did not quite cease may be accounted for by the fact that the younger circumferential wood was not completely cut through.

My apparatus would be also suitable for such experiments as those of Dufour (*Arbeiten d. Bot. Inst. in Würzburg*, 1884, Band iii.), in which he showed that sharply bending a stem, such as a hop-bind, does not prevent the passage of the water of transpiration, whereas water could not be mechanically forced through the bent stem. Dufour also repeated Hales' experiments in which the transpiring branch was cut half through on two opposite sides, the points of section being an inch or two apart. When this had been done, so that the continuity of all *cavities* of vessels and cells was broken, he found that the transpiration-stream could still pass, because the continuity of the cell-*walls* remained unbroken. I give a single experiment of this kind to show that my instrument is well adapted for such work (April 15):—

Time h. m.	Rate of Absorption
11 32	25
34	25
36	25
37½	first cut
39	22
49	24
55	second cut
12 2	0·84
22	0·69

Both cuts penetrated to the centre of the branch. The first was one and a half inch from the base, the second half an inch below the first cut, and on the opposite side of the branch.

Dufour's experiments would seem to show that the great depression in absorption which occurred on making the second cut may have been only a temporary phenomenon; this and other k ndred questions I hope soon to be able to work out.

FRANCIS DARWIN

Cambridge, April 17

[1] The young wood was not well severed, and a small amount remained in continuity.

WHAT IS A LIBERAL EDUCATION?[1]

I DO not intend, in the present paper, to enter upon the disputed question between the advocates of classical culture on the one hand, and those of scientific training on the other; because it seems to me that the line on which the two parties divide is not that which really divides the thought of the day. If we look closely into the case, we shall see that the objects of a higher education may be divided into three classes, instead of the two familiar ones of liberal and professional. In fact, what we commonly call a liberal education should, I think, have two separate objects. With the idea of a professional education we are all familiar: it is that which enables the possessor to pursue with advantage some wealth-producing specialty. Although, in accordance with well-known economic principles, it is designed to make the individual useful to his fellow-men, the ultimate object in view is the gaining of a livelihood by the individual himself. On the other hand, the object had in view in what is commonly known as culture is not the mere gaining of a livelihood, but the acquisition of those ideas, and the training of those powers, which conduce to the happiness of the individual. From this point of view culture may be considered an end unto itself.

The third object which we have to consider is only beginning to receive recognition in the eyes of the public. It is the general usefulness of the individual, not merely to himself and to those with whom he stands in business relations, but to society at large. Modern thought and investigation lead to the conclusion, that man himself, the institutions under which he lives, and the conditions which surround him, are subject to slow, progressive changes; and that it depends very largely on the policy of each generation of mankind whether these changes shall be in the way of improvement or retrogression. During the next fifty years all of us will have passed from the stage of active life, and the course of events will be very largely directed by men who are still unborn. The happiness of those men is, from the widest philanthropic point of view, just as important as the happiness of those who now inhabit the earth; and, in the light of modern science, we now see that that happiness depends very largely upon our own actions. We thus have opened out to us an interest and a field of solicitude in which we need the best thought of the time. The question is, What form of education and training will best fit the now rising generation for the duty of improving the condition of the generation to follow it?

Let it be understood that we are now speaking, not of the education of the masses, but of that higher education which is necessarily confined to a small minority. So far as I am aware, that fraction of the male population which receives a college education is not far from 1 per cent. To that comparatively small body we must look for the power which is to direct the society of the future, and by their acts to promote the well- or ill-being of the coming generation. Our duty to that generation is to so use and train this select body as to be of most benefit to the men of the future. What is the training required? I reply by saying that I know nothing better for this end than a wide and liberal training in the scientific spirit and the scientific method. The technicalities of science are not the first object; and, so far as they are introduced, it is only

[1] From *Science*.

as media through which we may imbue the mind with certain general and abstract ideas. If called upon to define the scientific spirit, I should say that it was the love of truth for its own sake. This definition carries with it the idea of a love of exactitude—the more exact we are the nearer we are to the truth. It carries with it a certain independence of authority; because, although an adherence to authoritative propositions taught us by our ancestors, and which we regard as true, may, in a certain sense, be regarded as a love of truth, yet it ought rather to be called a love of these propositions, irrespective of their truth. The lover of truth is ready to reject every previous opinion the moment he sees reason to doubt its exactness. This particular direction of the love of truth will lead its possessor to pursue truth in every direction, and especially to investigate those problems of society where the greatest additions to knowledge may be hoped for.

Scientific method we may define as simply generalised common sense. I believe it was described by Clifford as organised common sense. It differs from the method adopted by the man of business, to decide upon the best method of conducting his affairs, only in being founded on a more refined analysis of the conditions of the problem. Its necessity arises from the fact that, when men apply their powers of reason and judgment to problems above those of every-day life, they are prone to lose that sobriety of judgment and that grasp upon the conditions of the case which they show in the conduct of their own private affairs. Business offers us an example of the most effectual elimination of the unfit and of "the survival of the fittest." The man who acts upon false theories loses his money, drops out of society, and is no longer a factor in the result. But there is no such method of elimination when the interests of society at large are considered. The ignorant theoriser and speculator can continue writing long after his theories have been proved groundless, and, in any case, the question whether he is right or wrong is only one of opinion.

I ask leave to introduce an illustration of the possibilities of scientific method in the direction alluded to. Looking at the present state of knowledge, of the laws of wealth and prosperity of communities, we see a great resemblance to the scientific ideas entertained by mankind at large many centuries ago. There is the same lack of precise ideas, the same countless differences of opinion, the same mass of meaningless speculation, and the same ignorance of how to analyse the problem before us in the two cases. Two or three centuries ago the modern method of investigating nature was illustrated by Galileo, generalised by Bacon, and perfected by Newton and his contemporaries. A few fundamental ideas gained, a vast load of useless rubbish thrown away, and a little knowledge how to go to work acquired, have put a new face upon society. Look at such questions as those of the tariff and currency. It is impossible not to feel the need of some revolution of the same kind which shall lead to certain knowledge of the subject. The enormous difference of opinion which prevails shows that certain knowledge is not reached by the majority, if it is by any. We find no fundamental principles on which there is a general agreement. From what point must we view the problem in order to see our way to its solution?

I reply, from the scientific standpoint. All such political questions as those of the tariff and the currency are, in their nature, scientific questions. They are not matters of sentiment or feeling which can be decided by popular vote, but questions of fact, as effected by the mutual action and interaction of a complicated series of causes. The only way to get at the truth is to analyse these causes into their component elements, and see in what manner each acts by itself, and how that action is modified by the presence of the others: in other words, we must do what Galileo and Newton did to arrive at the truths of Nature. With this object in view, whatever our views of culture, we may let science, scientific method, and the scientific spirit be the fundamental object in every scheme of a liberal education.

S. NEWCOMB

THE KRAKATOA ERUPTION[1]

THE inquiry, instituted in consequence of a Government resolution of October 4, 1883, into the nature, the extent, and the consequences of the volcanic eruptions of Krakatoa, has led to various remarkable results of which a short account is given here. A detailed report is in course of preparation, but will not appear for some months, as the making of numerous illustrative maps and plates will take much time. The inquiry did not extend solely to the islands of the Straits of Sunda, but also to the coast countries of the Lampong districts, Bantam and Batavia, which were partly or entirely destroyed. In the Straits of Sunda the islands of Merak, Toppershoedje, Dwars in den Weg (Thwart the Way), Seboekoe, Sebesi, Lagoendi, Krakatoa, Taboean, Prince's Island, the Monnikrotsen (the Monk's Rocks), and Meeuwen Island (Mew's Island), were visited; further, the coast-strip from Ketimbang to Kalianda, and inland as far as Kesoegihan, besides the foot of the Radja Bassa; the coast of Hoeroen to Telok Betong, and the environs of the capital; the southern part of Semangka Bay (the northern part was inaccessible through pumice-stone), the kampoengs Tampang and Elimbing, near the Vlakken Hoek, Java's First Point (Java Head), and the coasts of Tjiringin and Anjer to Merak. The voyage, which lasted seventeen days, was made by the *hopperbarge* (small steamer) *Kediri*, commander 't Hoen, given for the inquiry by the temporary chief of the Batavian Harbour Works. About the causes of eruptions there is usually not much to be said, yet in this case something has been ascertained. Krakatoa, namely, lies with a few other volcanoes on a rent or fissure in the crust of the earth which runs across the Straits of Sunda, and of which I indicated the probable existence for the first time three years ago. Along such a fissure little shiftings of the earth's crust are possible, by which a pressure is exercised upon the molten substances below the crust. It is also possible that along such a rent—however tightly closed by the neighbouring stone-layers—the water may more easily than elsewhere flow to the regions under the earth. If this water comes in contact with the molten substances, steam at high temperature and high pressure is formed, and this steam may be considered as the chief motor of most, if not all, volcanic eruptions.

Many circumstances, therefore, combine to make eruptions take place in preference near fissures, provided water (either rain or sea-water) can penetrate in sufficient quantity. We must conclude from the 200 years' quietude of the volcanoes in the Straits of Sunda that the water affluence during that time was but small, and only became larger within the last years. Now it happens that during the last years a great many earthquakes took place along this fissure, of which the lighthouse on "Java's First Point" in particular suffered greatly. The most violent earthquake took place September 1, 1880; the upper part of the tower was rent, and had to be broken off afterwards. These earthquakes were probably the result of subterranean subsidences, and I think I may assume that through those subsidences modifications took place along the fissure through which the sea-water could ooze in greater quantity than before. Within the three last years the pressure of the steam formed became sufficiently strong to force the lava, out of the much deeper-lying lava strata, upwards through the crater of Krakatoa, and the eruption took place when, at last, the violence of the steam was enabled to force its way through the lava to the crater and the surface. The steam carried with it a

[1] Translation of a Short Report on the Eruption of Krakatoa on August 26, 27, and 28, 1883.